Incipient Forest Regeneration on Great Island, Three Kings Group.

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A previous paper (Baylis, 1948) attempted to trace the history of the vegetation on Great Island and reached the following conclusions. The bulk of the island was originally covered by mixed coastal forest. This was destroyed by a long period of Maori occupation, through which most of the component species probably persisted as single specimens and small groups. A period of regeneration, probably impeded to a small extent by goats, followed the departure of the Maoris about 1840, so that by 1889 a variety of shrubs and small trees mingled with a general covering of *Leptospermum*. Most of these failed to survive when the goat population grew large, and probably for about half a century prior to their complete destruction in May, 1946, these animals so thoroughly searched the island for food that trees other than two unpalatable species of *Leptospermum* were rarely, if ever, able to re-establish themselves from seed. Latterly *L. cricoides* (kanuka) had been more successful in this respect than *L. scoparium* (manuka), so that when the goats were destroyed, kanuka covered almost the entire island, the principal exception being a piece of *Zoisia* grassland. The trees of the mixed coastal forest persisted only as scattered individuals and small groups among which more than half the species were represented by five trees or less. At least two of the presumed components of this forest (*Meryta sinclairii* and *Elingamita johnsoni*) had disappeared entirely.

In 1946 most of the kanuka on Great Island was senescent and open. Since its seedlings are very intolerant of shade its re-establishment never occurred until the parent plants had died, and not always promptly then, sometimes through the presence of sedge undergrowth, sometimes—notably on the eastern plateau—because the soil was by this time windswept and eroded. The opportunities for entry of shade tolerant seedlings and even for light-demanding seedlings hardier than kanuka were thus extensive as soon as the goats ceased to make their establishment impossible. It did, however, appear that on the eastern plateau and elsewhere (e.g., the southern scrub area) the soil might have deteriorated overmuch for other trees, both through poor quality of *Leptospermum* humus (Scott Thomson and Simpson, 1937) and because of erosion in the replacement phases.

An account of a brief survey of Great Island in December, 1947, has already been published (Baylis, 1948). This paper sets forth observations I made in January, 1951, while encamped for six days on the island with a party organised for the Auckland Museum by its Director, Dr. Archey, and Ornithologist and Entomologist, Mr. Turbott, to whom I am much indebted for this opportunity. A re-charting of Turbott's (1946) quadrats was simultaneously undertaken. These charts are presented and discussed in an accompanying paper (Holds-

worth, 1951). Some results of a short visit that I was able to pay in January, 1950, through the kindness of Major M. E. Johnson are included here. Expenses have been met by a grant from the Research Fund of the University of New Zealand.

SEEDLING ESTABLISHMENT UP TO JANUARY, 1951.

Trees with seedlings intolerant of shade.

Only the species of *Leptospermum* and *Metrosideros excelsa* (pohutukawa) appear to fall in this class.

(a) *Leptospermum*

Shade tolerant tree-seedlings are not yet sufficiently widespread to cause a general halt in the cycle of death and re-growth of kanuka (*L. ericoides*). Nevertheless, over much of the island it no longer continues. In all moist places herbaceous undergrowth is tall and dense and promises to deny the ground to kanuka seedlings over much wider areas than hitherto, so that, though open patches of rank sedge or *Colensoa* are still few and small, they seem certain to increase (figs. 1 and 2).

The eastern plateau is dry, but here kanuka is encountering competition from manuka (*L. scoparium*). This was the area in which the latter species was in 1946 more plentiful than in any other part of the island. Nevertheless, it was much less in amount than kanuka, which appeared to be replacing it. It was here also that soil deterioration was most obviously retarding re-establishment when old *Leptospermum* died, so that there were many open places. Since removal of the goats there has been no obvious increase in the rate of colonisation of these spaces by kanuka, but many of them have filled with manuka seedlings (fig. 3). This suggests that manuka is the species better adapted to maintain itself on the drier parts of the island but that in the seedling stage it was the more liable to damage by goats. There remains little reason to doubt that considerable replacement of manuka by kanuka accompanied growth of the goat population between 1887 and 1945, and that the reverse change is now under way.

The *Zoisia* area is also a dry one and the grass has not grown too long to prevent a general invasion of the sward by kanuka seedlings (fig. 4). This is in accordance with the familiar invasion of mainland pasture by *Leptospermum* which occurs when stocking is inadequate (e.g., Levy, 1949), and the fact that *L. scoparium* is not present here also is accounted for by the remoteness of any seed source.

(b) *Metrosideros excelsa*

The pohutukawa is demonstrating its ability to invade a grass turf on part of the *Zoisia* sward, over about a quarter acre of which its seedlings promise to compete with kanuka for dominance (fig. 4). A few dozen plants have also established themselves on bare soil between kanuka bushes at one place on the eastern plateau (fig. 5). To a tree of this colonising power Bald Hill, the entire *Zoisia* area, the grassy interspaces of the adjacent kanuka scrub and all the open strips of the eastern plateau should be available; nevertheless, most of the pohutukawa standing on or close to these areas have as yet no seedlings associated with them.

Trees with shade-tolerant seedings.

The remaining trees have seedlings that are in some degree shade tolerant and can establish themselves under a mature or thinning canopy of kanuka—in fact, none are found making their initial growth wholly without such protection. These species are components of mixed coastal forest which is believed to be the climax vegetation.

(a) *Cordyline australis*

Cabbage trees were well dispersed over the island in 1945 and were flowering abundantly. Seedlings are now common in kanuka forest and shrubland, but since they remain unbranched for a long time and develop only a tufted crown this species may not exercise much controlling influence on others.

(b) *Meryta sinclairii*

Puka seedlings are now common on the slopes which face S.E. Bay east of the depot, i.e., in the vicinity of Quadrat I (fig. 6) and adjacently in the lower part of Castaway Valley. They grow rapidly and cast a heavy shade, so that it is possible that a puka canopy will develop over some of this area. Elsewhere under comparable conditions of soil and shelter this species is seen only occasionally. It is rare in Tasman Valley, and there are a few young plants under Hapuka Point and in the shelter of pohutukawa below Bald Hill.

Even Cheeseman did not record *Meryta* on Great I., which means that it is over 50 years since seeding trees grew there. If the possibility of buried seeds lying dormant for over half a century cannot be dismissed (Crocker, 1938), at least some unusual soil disturbance would be necessary to break the dormancy of such substantial numbers. It seems beyond reasonable doubt that puka forests on North-East I. and South-West I., particularly the former because of its proximity, are the main seed source and red-billed gulls (*Larus novaehollandiae*), whose droppings on Great I. have been found to contain *Meryta* seed, are the principal carriers. Many nest on the island's coast line and they are constantly to be seen hovering about the forest roof, a habit ascribed by Turbott (1951) to their feeding on cicadas. Admittedly, the part of Great I. closest to North-East I. is virtually devoid of *Meryta* seedlings. However, the depleted aspect of this eastern plateau area has already been mentioned, and the poor growth of the only young *Meryta* found upon it confirms the impression that it is at present inhospitable to that tree.

(c) *Brachyglottis arborescens*

The two moribund groves, and the few single trees along the western side of South East Bay are the nuclei of thickets of seedlings up to 6ft. high. That from the eastern grove extends for about 50yds. up the slope, that from the western grove for about 100 yards—in both cases beneath old kanuka (fig. 7). Occasional seedlings are seen much further from these sources, particularly on the northern side of South East Bay, but the species has yet to enter Tasman Valley.

(d) *Pittosporum fairchildii*

The large specimen close to the western *Brachyglottis* grove has several seedlings in its vicinity (fig. 8), and though it is dispersed by

birds and the *Brachyglottis* by wind, occasional young plants of both are met with comparable frequency on the high lying land between the parent trees and the summit of the island. The remaining *Pittosporum* trees are close to Quadrat I and from these there is little spread as yet.

(e) *Cyathea medullaris, Paratrophis smithii, Melicytus ramiflorus, Coprosma macrocarpa, Litsaea calicaris, Melicope ternata.*

Old trees grow at intervals among the Tasman Stream and young plants of all, and particularly of *Cyathea* (fig. 9), are now common in the valley bottom. A similar spread of *Litsaea, Paratrophis* (fig. 11), *Melicope* and *Melicytus* centres round the specimens in the valleys east of the depot. So far *Litsaea* alone is spreading actively from the clump of mixed trees in Castaway Valley, and here its exceptional shade tolerance is apparent, seedlings occurring beneath kanuka too dense to allow of any other undergrowth. *Cyathea* has not yet spread to Castaway Valley, but a few seedlings of *Coprosma macrocarpa* have appeared there.

(f) *Hiemerliodendron brunoniana, Planchonella costata var. austromontana (Sideroxylon novozelandicum), Olea apetala, Corynocarpus laevigata, Hedycarya arborea, Alectryon grandis, Vitex lucens*

These are all species with very few parent trees on the island and seedlings at present confined to the immediate vicinity of one or more of the specimens. The minimum increase is shown by *Vitex*. The two trees fruit well, but so far only one seedling has appeared. No seedlings of *Alectryon* were found by either of the trees on the 1945 map, but in its preparation a small gulley on the northern side of the northern headland of Tasman Bay was overlooked, and this proves to contain two further trees of *Alectryon* together with two *Planchonella* and six *Brachyglottis*. *Alectryon* seedlings are plentiful for about 50 yards along the gulley bottom. *Planchonella* has spread rather less, and *Brachyglottis* somewhat further.

(g) *Rapanea (Suttonia) dentata, Plectomirtha baylisiana*

Seedlings were not seen beside any of the existing trees of *Rapanea*. It has only been observed fruiting at Hapuka Point, where there were two trees together, one of which is now dead. Probably it is, like several of the genus, dioecious. Surprisingly, however, a few seedlings which seem to be of this species occur about the camp site in Castaway Valley —a full quarter mile from any mature tree.

The sole known tree of *Plectomirtha* has failed to establish any seedlings on the stony ground which surrounds it, although the adjacent *Olea* has done so. The nature of the ripe fruit is still unknown, and it may be that none has matured. Certainly many of the panicles decay soon after flowering.

Lianes.

Old vines of *Clematis paniculata (C. indivisa)* and *Tetrapathea tetrandra* in the valleys east of the depot have made rampant growth, and produced exceptionally large leaves. This applies especially to *Tetrapathaea*, which has also established abundant seedlings there.

Parsonia heterophylla and *Clematis* in the Tasman Valley have not as yet spread conspicuously, and there is no evidence that the single *Tecomanthe speciosa* vine has seeded though it is thriving and has layered itself at one point well removed from the old base.

Soft wooded species.

Three quickly maturing soft-wooded species have become conspicuous—*Entelea arborescens*, which is a small tree, *Solanum aviculare* var.*albiflora*, which is a shrub attaining a maximum height of about 8 feet, and *Colensoa physaloides*, which is a large herb forming hydrangea-like clumps up to 5 feet high (figs. 2, 9, 13). *Colensoa* was abundant in 1887 (Cheeseman, 1888) and a few plants persisted in damp places in 1945. Now it forms large patches both in the Tasman Valley and on the slopes which face S.E. Bay, east of the depot. The *Solanum* is most plentiful over the area in which *Meryta* is most abundant, and it seems likely that its seed came by the same means though its presence on North East I. is not established. In addition, it occurs by the western *Brachyglottis* grove (fig. 8). *Entelea* was collected on Great I. as late as 1934. Transport of its large burred fruits from adjacent islands is hard to imagine, and in the light of published work (Millener, 1949) it may be that the odd plants still appearing come from dormant seed, while the small thickets—one in the Tasman Valley and one by the western *Brachyglottis* grove—are the product of precociously fruiting plants.

Other shrubs and herbs.

When goats browsed beneath the kanuka in most places there was a turf in which *Gnaphalium collinum, Lagenophora pumila, Cotula australis, Haloragis procumbens* and *Centella asiatica* were prominent. These creeping plants have been displaced by a vigorous growth of the accompanying grasses coupled with a large increase in the frequency of some hitherto not plentiful, i.e., *Agropyron kirkii, Microlaena stipoides, Poa anceps, Poa seticulmis.* Quail are common and may have aided their dispersal. Two liliaceous herbs, *Dianella intermedia* and *Arthropodium cirrhatum*, have also become widespread. *Arthropodium* was previously restricted to inaccessible cliffs and *Dianella*, now specially abundant on the eastern slopes of Tasman Valley, was found chiefly on the eastern plateau.

A list of herbs which colonised bare soil and the finer scree material on cliffs soon after removal of the goats has already been given (Baylis, 1948). It is apparent that on sea-cliffs the prostrate ecotype of *Myoporum laetum* is gaining possession, but on Bald Hill (fig. 10) the only woody plant so far established is the endemic *Hebe insularis.* No form of *Myoporum* capable of developing into a tree is present on Great Island. Seedlings often appear on the hills, but their growth is spindly and they soon die.

Additions to the species list since December, 1947.

In December, 1947 (Baylis, 1948), 18 species were collected that had not been observed while goats were plentiful, though the possibility of their being present in out of the way places could not be precluded.

The following are now added with the same reservation. The date (1887) or (1889) means that the species was recorded by Cheeseman (Oliver, 1948), though it is possible that 1889 records relate not to Great I. but to South-West I.

Anagallis arvensis L.
Arthropteris tenella (Forst. f.) Sm. (1889).
Bromus catharticus Vahl.
Calystegia soldanella R. Br.
Calystegia tuguriorum (Forst. f.) R. Br. (1887).
Erechtites atkinsoniae F. Muell.
Erigeron canadensis L.
Hierochloe redolens R. Br.
Paspalum scrobiculatum L. (1889).
Polystichum richardi (Hook.) Sm. (1887).
Sarcochilus adversus (Hook. f.).
**Solanum aviculare* Forst. f. var. *albiflora* Cheesem. (1889).
Trifolium glomeratum L.
Uncinia uncinata (L) Kirk (1887).
Veronica plebeia R. Br.

DISCUSSION.

All species that were expected to occupy more ground after removal of the goats have begun to do so except the two rarest, *Tecomanthe* and *Plectomirtha*, each of which is still represented by a single plant that may not have fruited.† The short life cycle of the herbs has enabled some to spread extensively, the most striking examples being *Colensoa*, *Arthropodium*, *Dianella* and two grasses, *Agropyron kirkii* and *Microlaena stipoides*, both first noticed in 1947 and now widely diffused. The distribution of woody species, however, remains in general closely related to the seed source. Even *Meryta* and *Solanum* which seem to have come from a distance show this. Though birds appear to have carried these species from other islands they have failed as yet to bring in *Macropiper* in comparable quantity. The only markedly discontinuous dispersal observed upon Great I. itself was the presence of *Rapanea* and *Coprosma macrocarpa* at the camp site in Castaway Valley. As the headquarters of collectors this place is suspect. Striking examples of persistent localisation are *Cyathea* and *Tetrapathaea*, both still restricted to the valleys containing the parent plants, but spreading abundantly there.

Chance factors of distribution promise to exercise a major influence on the composition of the new forest. These include the position of the old forest relics; how far the ground immediately about each tree was

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*Seedlings seen in 1947 were identified as the type, but the flowers prove to be paler, the habit more slender, and the leaves unlobed except in the seedling stage. Cheeseman's record is simply *S. aviculare*, but he did not erect the variety until 1920.

†Mr. J. Horton has successfully propagated *Tecomanthe* from cuttings at the Plant Diseases Division, Auckland. Further attempts will be made to establish *Plectomirtha* by this means.

suitable for seedlings and thereby for an early increase in seed production close to the original centre; whether or not in the first few years any seedlings arose at a distance to become separate centres of seed supply.

A character which should assist some species is precocious fruiting. The oldest seedlings of the fast growing trees *Brachyglottis, Meryta* and *Hiemerliodendron* (fig. 12) are already themselves in flower, the first two sometimes bearing an inflorescence when only two feet high. Another distributional accident which may prove significant is the extent to which ground adjacent to parent trees came early within the orbit of aggressive temporary occupants. In this role *Solanum aviculare* var. *albiflora, Colensoa* and *Entelea* are becoming conspicuous. Even a dense sedge growth, since it is capable of excluding kanuka, can in the absence of other seedlings cause local deforestation.

It will be interesting to observe which tree first secures all stations suited to it. The progress of *Meryta* in view of its abundance on North-East I. and South-West I. may be rapid when the seed supply is augmented by a substantial seed crop on Great I. itself. However, the exploration of these lesser islands is affording evidence that pure stands of this araliad are not, as was earlier suggested (Baylis, 1948), a stable climax even close to the sea.

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